Illustration of Suckermouth Minnow Larvae and Early Juveniles

Final Report

Prepared for

Ryan Fitzpatrick

Aquatic Wildlife Research Group
Colorado Parks and Wildlife
Fort Collins Research Center
317 West Prospect Street
Fort Collins, Colorado 80526

28 February 2014

By

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Larval Fish Laboratory
Contribution 182

Colorado State University

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Background:

The suckermouth minnow *Phenacobius mirabilis* (Cyprinidae) is the most widespread of five species in this genus, and the only one found in the midwest and central plains; the others are more eastern species with much smaller ranges, only one of which marginally overlaps that of suckermouth minnow (Lee et al. 1980, Page and Burr 1991). It is native to the Mississippi River Basin, including the Ohio and Missouri River Basins, with isolated populations in western Lake Erie drainages and some Gulf Coast rivers in Texas. The western extent of its native range includes the eastern plains of Colorado, Wyoming, and New Mexico where populations have declined (Propst 1999, Bestgen et al. 2003, Wyoming Game and Fish Department 2010, New Mexico Department of Game and Fish 2012).

In Colorado, the suckermouth minnow is a state endangered species that was historically widespread in eastern plains and some foothills stream reaches of the South Platte River Basin, the Arikaree and Republican River Basins, and eastern plains reaches of the Arkansas River Basin. More recently it has been found only in the lower South Platte River and tributary Lodgepole Creek and in the Arkansas River below John Martin Reservoir and tributaries Big Sandy Creek, Cheyenne Creek, and Purgatoire River (Bestgen et al. 2003). In an effort to re-establish the species in former native habitat, the Colorado Parks and Wildlife (CPW) John Mumma Native Aquatic Species Restoration Facility successfully reared and stocked about 4,000 suckermouth minnows in the Arkansas River above John Martin Reservoir in late 2011 (Colorado Parks and Wildlife 2011).

To the north and south, the suckermouth minnow is considered respectively a Wyoming "imperiled" and New Mexico threatened species. In Wyoming, it was historically present in the North Platte River and its Lower Laramie River and Horse Creek tributaries, but more recently it has been found only in Horse Creek (Wyoming Game and Fish Department 2010). In New Mexico, it was historically present in the Canadian and Dry Cimarron River drainages, but is now rare in the former and appears to have been extirpated from latter; also, a sparse introduced population remains in the Pecos River (Sublette et al. 1990, Propst 1999, New Mexico Department of Game and Fish 2012).

The suckermouth minnow is a moderately slender, terete minnow, usually maturing by age 2 and measuring up to 6.5 to 10 cm total length (TL), with a maximum length of about 12 cm and lifespan of 4, possibly 5 years. As its common name suggests, it has a subterminal to inferior sucker-like (catostomid) mouth with prominent, fleshy, but widely-separated lower-lip lobes and a protractile upper jaw. The mouth lacks barbels and ends anterior to moderately small eyes that are positioned high on the head. The fish is also characterized by a long, blunt snout (notably longer than eye diameter); four narrow, slightly hooked, pharygeal teeth in a single row on each side of the throat; a total of five to nine short, knoblike, gill rakers; a short S-shaped gut with a silvery, but speckled, peritoneum; a complete, straight to slightly decurved or arched lateral line with 40-51 (usually 43-49) scales; scales that are lightly to darkly outlined with pigment on the upper body and absent ventrally on the anterior abdomen; and a dorsal fin origin anterior to the pelvic fins. Median fin principal ray counts are typically 8 (range 7-8) dorsal, 7 (6-7) anal, and 19 (19-20) caudal; paired fin total ray counts are typically 14 (13-17) pectoral and 8 (7-9) pelvic. Males have larger paired fins than females. The body is usually dark (gray, brown, or silvery green to olive brown or a yellowish hue) above a dusky (sometimes obscure) to dark lateral band and light (silvery or creamy to white) below with typically unpigmented pelvic and anal fins. The lateral band ends in a prominent, black caudal spot. Breeding males may be more yellowish with iridescent blue and silver spots and small tubercles over the head, anterior body, and pectoral fin; females are occasionally tuberculate on top of the head. (References: Lee et al, 1980, Becker 1983, Woodling 1985, Sublette et al. 1990, Page and Burr 1991, Pflieger 1997, Propst 1999, Texas State University 2013, Bestgen In-press.)

Primarily a benthic insectivore, the suckermouth minnow typically inhabits riffles and faster runs over sand and gravel substrate in small permanent streams to large rivers of low to moderate gradient; in drought-affected streams, it takes refuge in deeper pools (Bestgen et al. 2003, Texas State University 2013, Bestgen In-press). Spawning probably occurs over gravel riffles during a rather protracted season from April through August at 14-25°C (Becker 1983, Pflieger 1997, Bestgen et al. 2003, Bestgen In-press).

Bestgen et al. (2003) and Bestgen and Compton (2007) documented successful laboratory spawning by hormone-injected adults in 2002. Spawning was observed in flowing water over gravel and cobble, but not sand. Fish chased each other rapidly in circles over the substrate, males nudged females near the vent, pairs aligned themselves side-by-side, dipped their anal fins to the substrate, and vibrated together with females releasing one to a few eggs at a time. Spawning acts continued several times a minute during the first 15 minutes, then less frequently for at least the 3-h observation period. Adults probed the spawning substrate after spawning, probably feeding on recently spawned eggs.

With artificially fertilized eggs, they also reared suckermouth minnow and preserved developmental series for future reference and study. They reported that at 1 h after fertilization, eggs were spherical, 1.55-1.70 mm in diameter, demersal, adhesive, and dark yellow to golden in color (however, preserved diameters for 27 older eggs recorded in Appendix II of Bestgen et al. 2003 averaged 1.7 mm with a range of 1.5-1.8 mm; also, five eggs preserved by the John Mumma Native Aquatic Species Restoration Facility for the Colorado State University Larval Fish Laboratory (LFL) were recorded to be 1.9-2.0 mm in diameter). Four-cell blastodiscs were evident by 4 h after fertilization. By 24 h, embryos incubated at 17 and 19°C were unpigmented with notochords just forming whereas those incubated at 23°C had pigmented eyes and obvious notochords (presence of eye pigmentation may have been misreported–we did not observe it in 2-d old embryos preserved from the same 23°C series). Functional hearts, visible myomeres and otoliths, and tails free from the yolk were first observed at 72 h and hatching at 96 h for embryos incubated at 17 and 19°C but at 48-52 h and 72 h, respectively, for those reared at 23°C. Regardless of temperature, most hatching was completed within the next 12 h, yielding larvae 4.2-4.8 mm TL ($\bar{x}$ = 4.6 mm; unreported lengths for ten larvae preserved a day later were similarly 4.3-4.8 mm except for one specimen measuring 5.3 mm). Fish reared at 17-19°C began feeding at 8 d posthatch and grew an average of 0.35 mm/d to a mean TL of 36 mm by 104 d posthatch; those reared at 23°C began feeding at 5 d and grew an average of 0.57 mm/d to a mean TL of 49 mm by 85 d.

Morphological development of suckermouth minnow embryos, larvae, and early juveniles have otherwise not been illustrated or described except for several field-collected late protolarvae (6.6-7.8 mm TL, with yolk) and recently transformed flexion mesolarvae (8.0 mm TL, without yolk) which were photographically illustrated (included a dorsal and a ventral view) and described by Perry (1979) in an appendix to his Master's thesis describing the larvae of nine other cyprinids. For the late protolarvae, he reported that their predorsal (finfold) lengths were 36-38% of TL, snout-to-vent lengths 61-65% of TL, preanal myomeres 25-26, postanal myomeres 12-13, snouts protruding and shelf-like, mouths inferior and horizontal, dorsums unpigmented except for a few melanophores in the occipital region, and ventrums with irregular lines of melanophores along each side of the ventral midline from heart to vent, at least partially, especially anteriorly, outlining the ventro-lateral aspects of their guts. He also reported that the larvae had large pectoral fins, developed a dorsal fin anlage (thickened base) well anterior to mid-body, and completed yolk absorption by about 8.0 mm TL. His photographs included lateral views for three specimens, and dorsal and ventral views for one specimen each, but unfortunately available scans or photocopies of the photographs are not very clear. Much of Perry's description was incorporated in a diagnostic comparison of cyprinid larvae from eastern North America by Fuiman et al. (1983) and has since been referenced therefrom by Sublette et al. (1990) and Texas State University (2013).

Objective:

Successful research and monitoring of fish reproduction and early life history often depends on detailed and well-illustrated descriptions for accurate identification of collected larvae and early juveniles. Collections of these early life stages can help define spawning grounds, seasons, and requirements, as well as assess larval and juvenile fish production, survival, transport, migration, habitat use, and susceptibility to entrainment in water diversions and other impacts. Furthermore, the morphological ontogeny of a fish often correlates with, and is useful in understanding, other aspects of its early life history–physiology, ecology, behavior, and the effects of environmental stressors.

To that end, the objective of this project was to more completely document the early morphological development of the suckermouth minnow with detailed, three-view drawings from recently hatched protolarvae to relatively late young-of-the-year juveniles. Like other larval and juvenile fish drawings previously prepared for CPW (i.e., Snyder and Bjork 2011 for mountain whitefish and 2012 for plains topminnow), these drawings are intended to aid identification of field-collected specimens and for future use in detailed descriptions and other pertinent reports and publications by, for, or with the permission of the CPW and (or) LFL. Future detailed descriptions could be prepared as a stand-alone descriptive species account (e.g., Snyder et al. 2011 for woundfin and 2013 for Virgin spinedace), included in a comparative description (e.g., Martinez 1983 and 1984 for brook, brown, rainbow, and cutthroat trout), and (or) incorporated in regional guides and keys (e.g., Snyder and Muth 2004 for catostomid larvae and juveniles of the Upper Colorado River Basin and Snyder et al. 2005 for cypriniform larvae and juveniles of the Gila River Basin).

Methods:

All drawing specimens, except the primary specimen for the later juvenile drawing, were selected from developmental series (4.2-51.5 mm TL) reared and preserved by LFL from 25 May through 9 September 2002 as part of an investigation for the Colorado Division of Wildlife (Bestgen et al. 2003, Bestgen and Compton 2007). The reproductively ready adults for that culture effort were collected a couple days earlier from the Purgatoire River (near Las Animas, Colorado) and transported to the CSU Aquatic Research Laboratory where they were hormone-injected the next day, held overnight, and stripped to artificially fertilize the eggs. A few protolarvae (4.7 and 6.1-6.7 mm TL) reared and preserved by the CPW John Mumma Aquatic Species Restoration Facility in 2009 and preserved juveniles (≥24 mm TL) collected from the Arkansas, Purgatoire, and South Platte Rivers (Prowers, Bent, and Logan Counties, respectively,

Colorado) in 2001-2006 were also available for consideration. The primary drawing specimen for the later juvenile illustration was selected from the latter. All specimens considered and used for this project were fixed in 10% formalin and have been subsequently maintained in 3% phosphate-buffered formalin as part of the LFL Collection.

Drawings were prepared 8-inch long on 8.5 x 11 inch white translucent vellum paper using continuous-tone graphite (pencil) and black ink. Black ink was used only to represent surface or near-surface pigmentation and distinguish it from deeper pigmentation, other structures, and shading. Each drawing includes three views portraying the dorsal, lateral, and ventral aspects of the fish–for many species, structure and pigmentation patterns in dorsal and ventral views are useful in the identification of wild-caught specimens. Specimens of typical appearance in good to excellent condition (straight with well-spread fins and little to no damage) were selected as primary, secondary, and often tertiary drawing specimens for each stage to be illustrated. The basic outlines and features of each view were traced from enlarged digital images of the primary drawing specimen to assure proportionally accurate dimensions and position of body structures. Various structures were checked and detail added while drawing specimens were examined under a microscope. If necessary, drawings were idealized (e.g., closed or frayed fins opened and smoothed and curved bodies straightened), and modified to better represent typical melanophore distribution and structure based on secondary and sometimes tertiary drawing specimens (however, only the sources of the primary drawing specimens are included in associated figure legends). Preliminary, base, and final drawings were critically reviewed to further assure accurate representation of the illustrated fish. Completed drawings were professionally scanned and processed as high-, medium-, and low-resolution digital files for storage, copy, transfer, print reproduction, and electronic display. Prints of the drawings are included at the end of this report in a size and format typically used by LFL for its descriptive species accounts. The original drawings are stored and maintained by LFL.

We typically illustrate up to eight stages to adequately portray the morphological development of fish larvae and early juveniles–specifically recently transformed and later stages of the protolarval, mesolarval, and metalarval phases of the larval period and also of the early (young-of-the year) portion of the juvenile period. The specific stages selected for illustration were a recently hatched protolarva (4.7 mm TL), a later protolarva with yolk (6.5 mm TL), a recently transformed flexion mesolarva (first caudal fin rays formed, 8.4 mm TL), a postflexion mesolarva (all principal caudal fin rays formed and notochord flexed upward, 10.5 mm TL), a recently transformed metalarva (all principal dorsal and anal fin rays present and pelvic fins or buds present, 14.2 mm TL), a later metalarvae (very nearly juvenile except not all pectoral fin rays present, 17.1 mm TL), a recently transformed juvenile (adult counts of all fin rays present and median finfold absorbed; 22.0 mm TL), and later young-of-the-year juvenile (40.2 mm TL).

Results and End Products:

The results of this project consist of eight detailed, three-view illustrations that document the early morphological development of suckermouth minnow from a recently hatched 4.7 mm TL protolarva to a 40.2 mm TL young-of-the-year juvenile (Figures 1-8). Notable features include: 1) a mouth that forms and remains in a subterminal to ventral position; 2) prominent, widely separated lower-lip lobes beginning with flexion mesolarvae; 3) eyes that are dorso-ventrally flattened in protolarvae, becoming deltoid in mesolarvae through recently transformed juveniles; 4) unusually large pectoral fin buds in later protolarvae and mesolarvae; 5) a dorsal fin origin anterior to pelvic fin origin beginning in metalarvae; 6) a very sparsely pigmented dorsum in protolarvae and flexion mesolarvae; 7) a more, but variably pigmented ventrum between heart and vent in late protolarvae and mesolarvae, often at least partially outlining the ventrolateral aspects of the gut anteriorly and the ventral finfold posteriorly; 8) a dark caudal spot forming in recent metalarvae and becoming prominent in later metalarvae and juveniles; and 9) prominent patterns of sensory papillae on the lower lateral and ventral surfaces of the head from postflexion mesolarvae through recently transformed juveniles. Our drawings of a late protolarva and recently transformed flexion mesolarvae match quite well with Perry's (1979) descriptions and photographs of specimens for the same developmental interval.

Much morphometric and meristic data also can be extracted from the drawings. For example, these specimens have: 1) snout-to-vent lengths of 70 %SL or 68 %TL for the recently hatched protolarva to 65 %SL or 53 %TL for the later juvenile (62-63 %TL for the later protolarva and flexion mesolarva–within the range reported by Perry 1979); 2) myomere counts of 25-27 anterior to the posterior margin of the vent (including those partially transected by a vertical line therefrom) and 11-13 posterior to the vent) for a total of 38-39 in the protolarvae and mesolarvae; and 3) juvenile fin-ray and scales counts that are consistent with those summarized above for adults.

A CD (compact disk) with copies of high-, medium-, and low- resolution digital images (cleaned scans) of the eight drawings was prepared for CPW archival storage and use and will be submitted to CPW with a printed copy of this report. Additional copies of the CD or specific image files can be provided to CPW upon request.

Acknowledgments:

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Literature Cited:

Becker, G. C. 1983. Fishes of Wisconsin. University of Wisconsin Press, Madison.

Bestgen, K. R., and R. I. Compton. 2007. Reproduction and culture of suckermouth minnow. North American Journal of Aquaculture 69: 345-350.

Bestgen, K. R., K. A. Zelasko, and R. I. Compton. 2003. Environmental factors limiting suckermouth minnow *Phenacobius mirabilis* populations in Colorado. Final report of Colorado State University Larval Fish Laboratory to Colorado Division of Wildlife, Fort Collins (LFL Contribution 136).

Bestgen, K. R. In-press. Suckermouth minnow *Phenacobius mirabilis* (Girard 1856). Pages 226-227 *in* Kansas Fish Committee, editors. Kansas Fishes. University Press of Kansas, Lawrence.

Colorado Parks and Wildlife. 2011. Rare minnows restored to Arkansas River. News about Colorado's Natural Resources, Press Release 12/12/2011, Colorado Parks and Wildlife Website–http://wildlife.state.co.us/NEWSMEDIA/PRESSRELEASES/Pages/index.aspx (February 2014).

Fuiman, L. A., J. V. Conner, B. A. Lathrop, G. L. Buynak, D. E. Snyder, and J. J. Loos. 1983. State of the art of identification for cyprinid fish larvae from eastern North America. Transactions of the American Fisheries Society 112:319-332.

Texas State University. 2013. *Phenacobius mirabilis* suckermouth minnow. Texas Freshwater Fishes Website, Department of Biology, Texas State University, San Marcos–http://txstate.fishesoftexas.org/phenacobius%20mirabilis.htm (February 2014; University of Texas Austin mirror of http://bio.txstate.edu/~tbonner/txfishes/).

Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina Biological Survey Publication 1980-12. North Carolina State Museum of Natural History, Raleigh.

Martinez, A. M. 1983. Identification of brook, brown, rainbow, and cutthroat trout. Master's thesis. Colorado State University, Fort Collins.

Martinez, A. M. 1984. Identification of brook, brown, rainbow, and cutthroat trout larvae. Transactions of the American Fisheries Society 113: 252-259.

New Mexico Department of Game and Fish. 2012. Threatened and endangered species of New Mexico, 2012 biennial review. Conservation Services Division, New Mexico

Department of Game and Fish, Santa Fe. Available: http://www.wildlife.state.nm.us/conservation/documents/2012BiennialReviewFinal.pdf (February 2014).
Page, L. M., and B. M. Burr. 1991. A field guide to freshwater fishes, North America north of Mexico (Peterson field guide series). Houghton Mifflin Company, Boston, Massachusetts.
Perry, L. G. 1979. Identification of nine larval cyprinids inhabiting small northern rivers. Master's thesis, Part 1, Iowa State University, Ames.
Pflieger, W. L. 1997. The fishes of Missouri, revised edition. Missouri Department of Conservation, Jefferson City.
Propst, D. L. 1999. Threatened and endangered fishes of New Mexico. Technical Report 1. New Mexico Department of Game and Fish, Santa Fe.
Snyder, D. E., and C. L. Bjork. 2011. Illustration of mountain whitefish larvae and early juveniles. Final report of Colorado State University Larval Fish Laboratory to Colorado Division of Parks and Wildlife Aquatic Research Group, Fort Collins (LFL Contribution 167).
Snyder, D. E., and C. L. Bjork. 2012. Illustration of plains topminnow larvae and early juveniles. Final report of Colorado State University Larval Fish Laboratory to Colorado Division of Parks and Wildlife Aquatic Research Group, Fort Collins (LFL Contribution 172).
Snyder, D. E., and R. T. Muth. 2004. Catostomid fish larvae and early juveniles of the Upper Colorado River Basin–morphological descriptions, comparisons, and computer-interactive key. Colorado Division of Wildlife Technical Publication 42. Available: http://warnercnr.colostate.edu/lfl-downloadable-keys-guides-and-bibliography (February 2014).
Snyder, D. E., K. R. Bestgen, and S. C. Seal. 2005. Native cypriniform fish larvae of the Gila River Basin–morphological descriptions, comparisons, and computer-interactive keys. Final report of Colorado State University Larval Fish Laboratory to U.S. Department of the Interior Bureau of Reclamation, Phoenix, Arizona (LFL Contribution 143). Available: http://warnercnr.colostate.edu/lfl-downloadable-keys-guides-and-bibliography (February 2014).
Snyder, D. E., J. A. Charles, and C. L. Bjork. 2011. Illustration and description of woundfin larvae and early juveniles—contribution to a guide to larval fishes of the Virgin River. Final report of Colorado State University Larval Fish Laboratory to Virgin River Resource Management and Recovery Program, Salt lake City, Utah (LFL Contribution 164).
Snyder, D. E., S. C. Seal, and C. L. Bjork. 2013. Illustration and description of Virgin spinedace larvae and early juveniles—contribution to a guide to larval fishes of the Virgin River. Final report of Colorado State University Larval Fish Laboratory to Virgin River Resource Management and Recovery Program, Salt lake City, Utah (LFL Contribution 178).
Sublette, J. E., M. D. Hatch, M. Sublette. 1990. The fishes of New Mexico. University of New Mexico Press, Albuquerque.
Woodling, J. 1985. Colorado's little fish: a guide to the minnows and other lesser known fishes in the state of Colorado. Colorado Division of Wildlife, Denver.
Wyoming Game and Fish Department. 2010. Suckermouth minnow - *Phenacobius mirabilis* (species account). Section IV-3, pages 86-87 *in* State Wildlife Action Plan - 2010. Wyoming Game and Fish Department, Cheyenne. Available: http://wgfd.wyo.gov/web2011/Departments/Wildlife/pdfs/SWAP_2010_FULL_OCT0003090.pdf (February 2014).

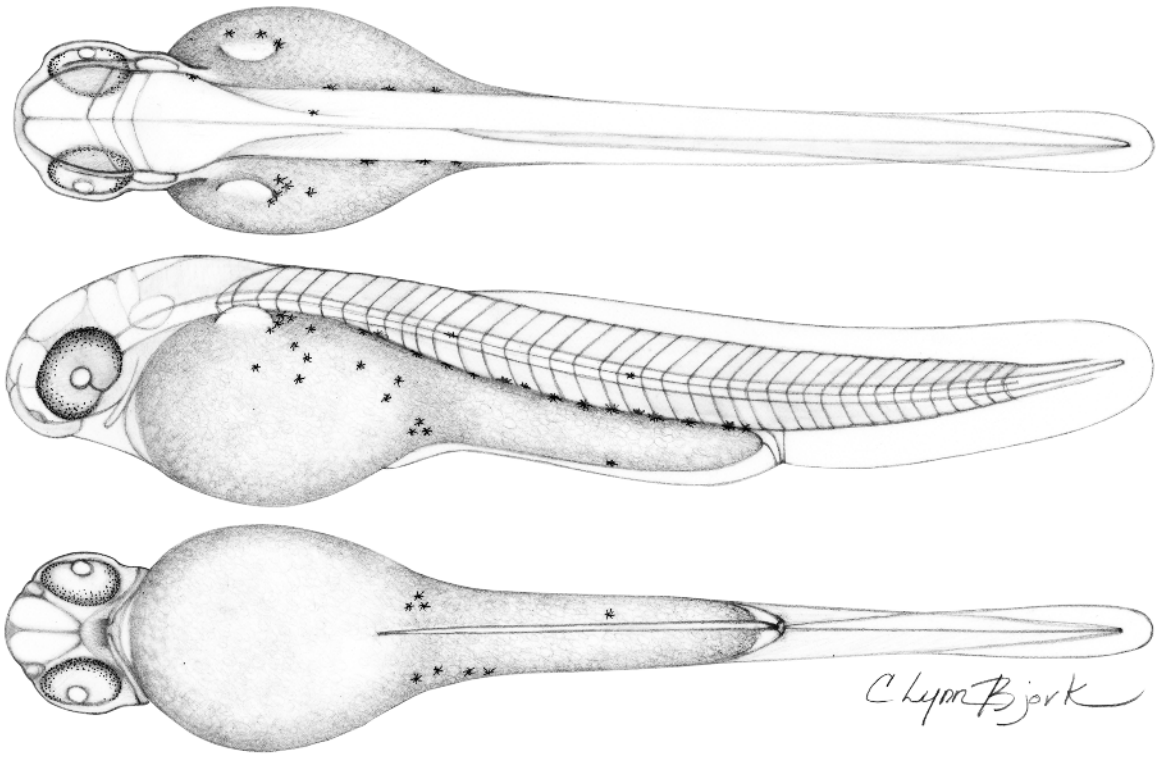

Fig. 1. *Phenacobius mirabilis* protolarva, recently hatched, 4.6 mm SL, 4.7 mmTL, 1 d posthatch at 17-19°C. (Cultured in 2002 by Colorado State University Larval Fish Laboratory with stock from the Purgatoire River near Las Animas, Colorado.)

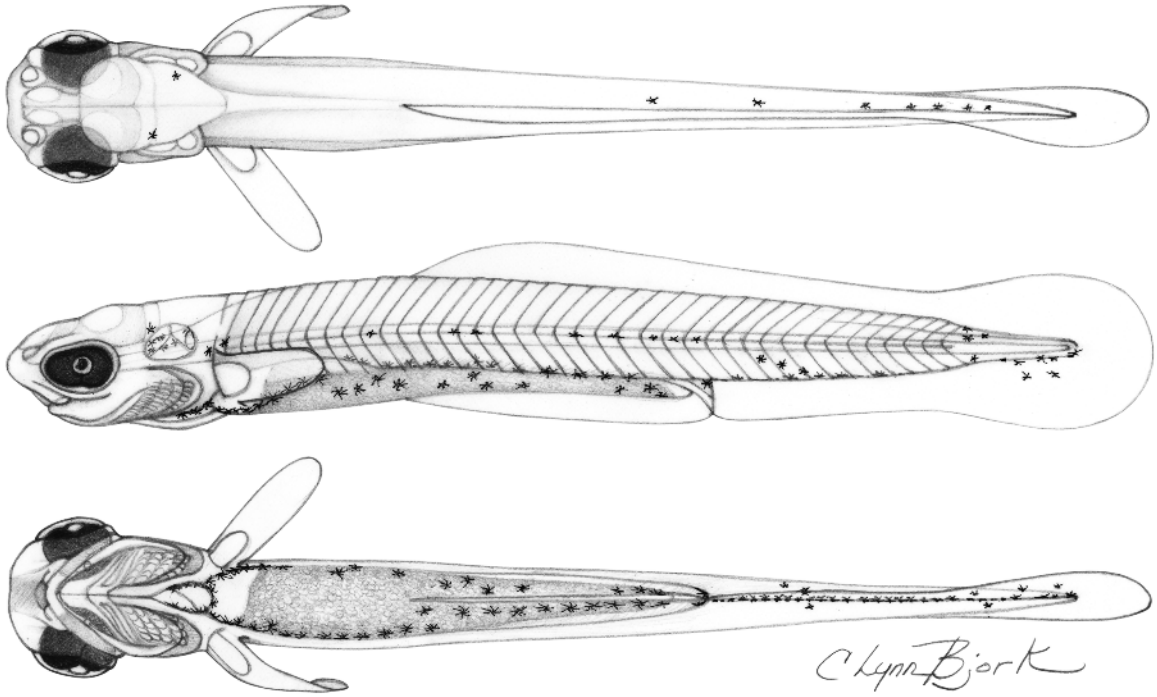

Fig. 2. *Phenacobius mirabilis* protolarva with yolk, 6.0 mm SL, 6.5 mm TL, 6 d posthatch at 17-19°C. (Cultured in 2002 by Colorado State University Larval Fish Laboratory with stock from the Purgatoire River near Las Animas, Colorado.)

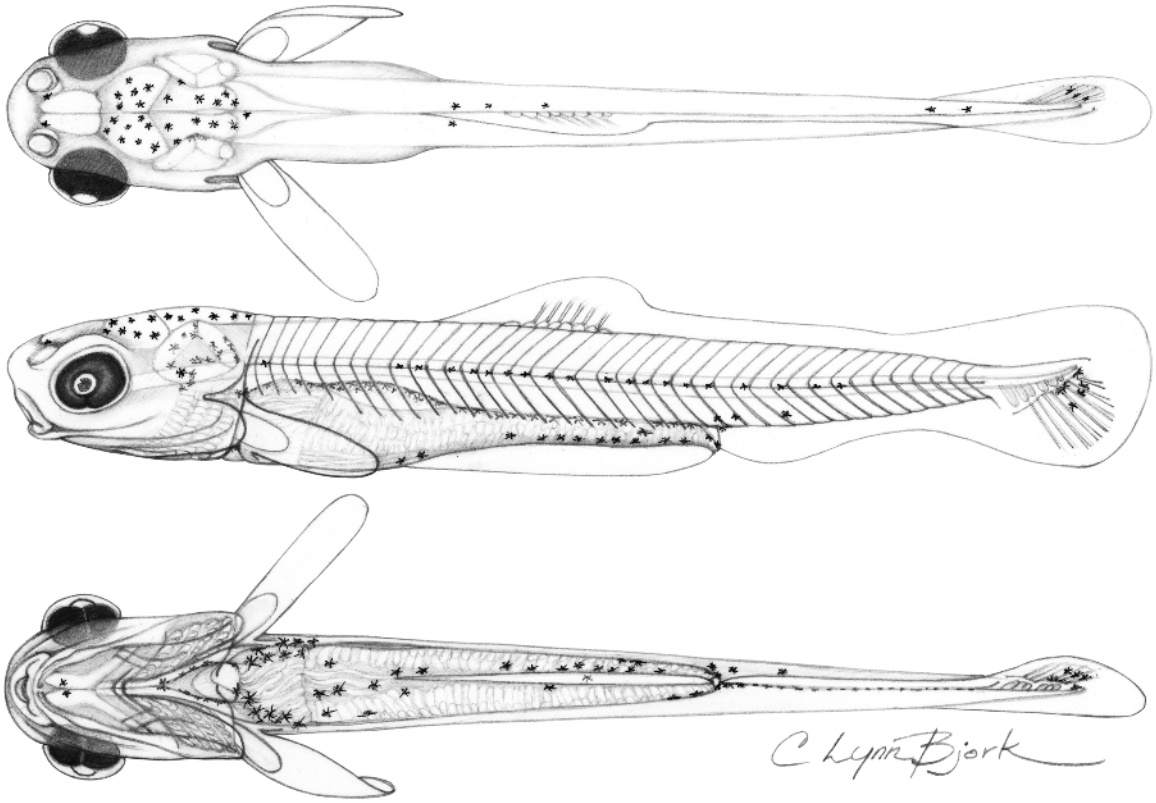

Fig. 3. *Phenacobius mirabilis* flexion mesolarva, recently transformed, 7.8 mm SL, 8.4 mm TL, 16 d posthatch at 17-19°C. (Cultured in 2002 by Colorado State University Larval Fish Laboratory with stock from the Purgatoire River near Las Animas, Colorado.)

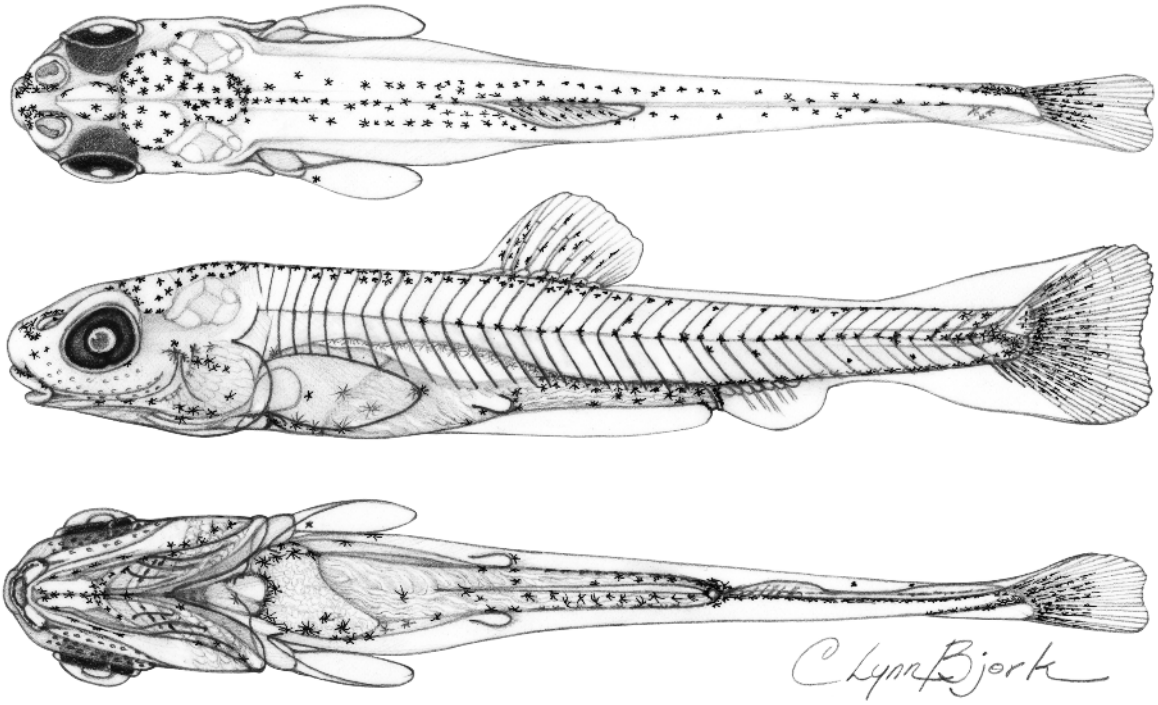

Fig. 4. *Phenacobius mirabilis* postflexion mesolarva, 9.5 mm SL, 10.5 mm TL, 16 d posthatch at 23°C. (Cultured in 2002 by Colorado State University Larval Fish Laboratory with stock from the Purgatoire River near Las Animas, Colorado.)

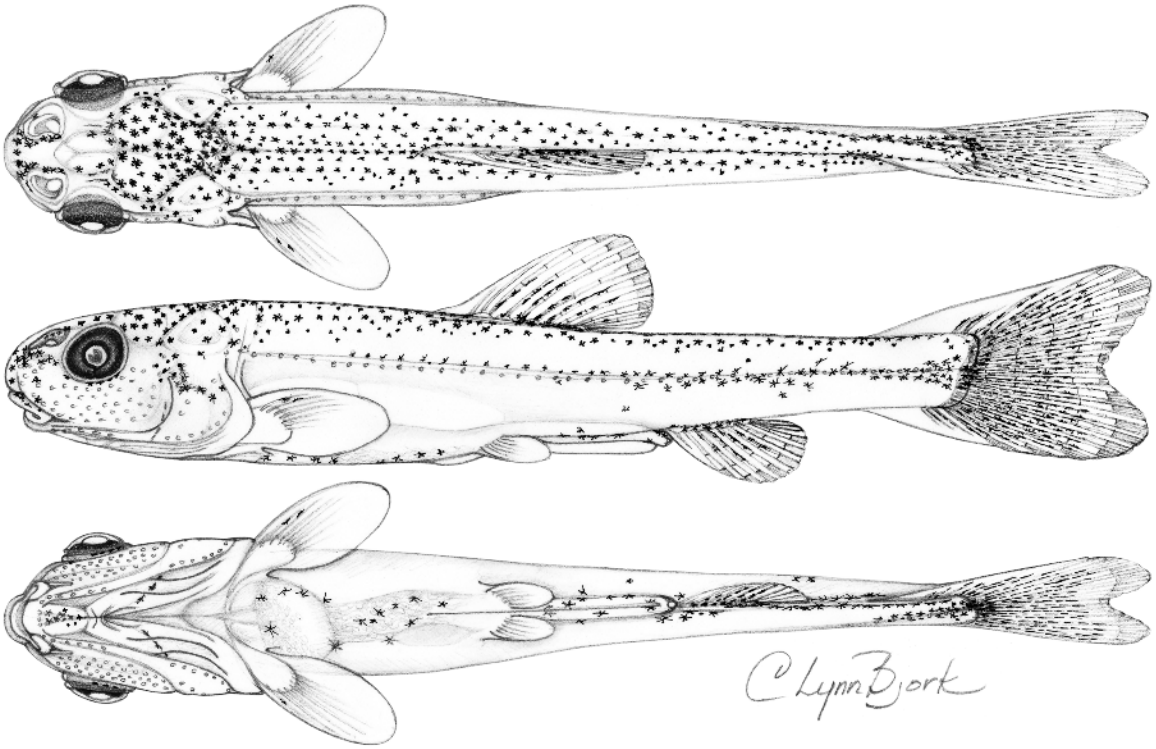

Fig. 5. *Phenacobius mirabilis* metalarva, recently transformed, 12.1 mm SL, 14.2 mmTL, 30 d posthatch at 17-19°C. (Cultured in 2002 by Colorado State University Larval Fish Laboratory with stock from the Purgatoire River near Las Animas, Colorado.)

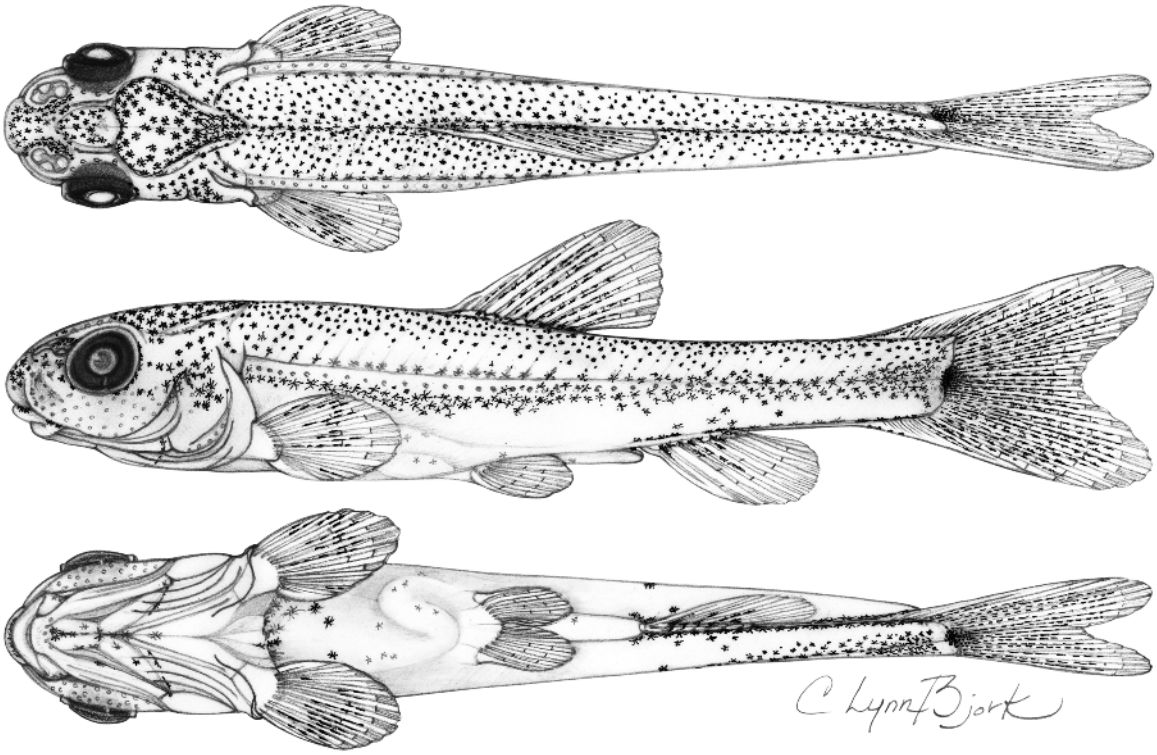

Fig. 6. *Phenacobius mirabilis* metalarva (almost juvenile but pectoral fin incomplete), 14.2 mm SL, 17.1 mm TL, 37 d posthatch at 17-19°C. (Cultured in 2002 by Colorado State University Larval Fish Laboratory with stock from the Purgatoire River near Las Animas, Colorado.)

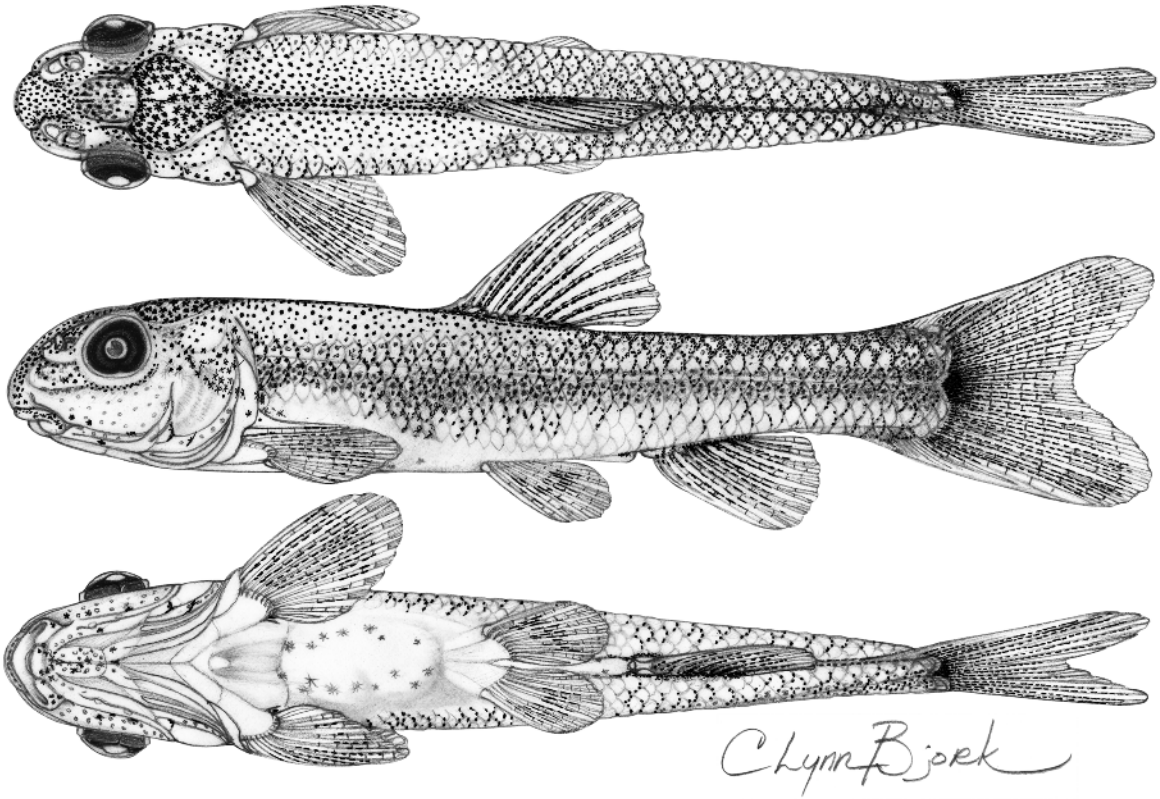

Fig. 7. *Phenacobius mirabilis* juvenile, recently transformed, 18.1 mm SL, 22.0 mm TL, 49 d posthatch at 17-19°C. (Cultured in 2002 by Colorado State University Larval Fish Laboratory with stock from the Purgatoire River near Las Animas, Colorado.)

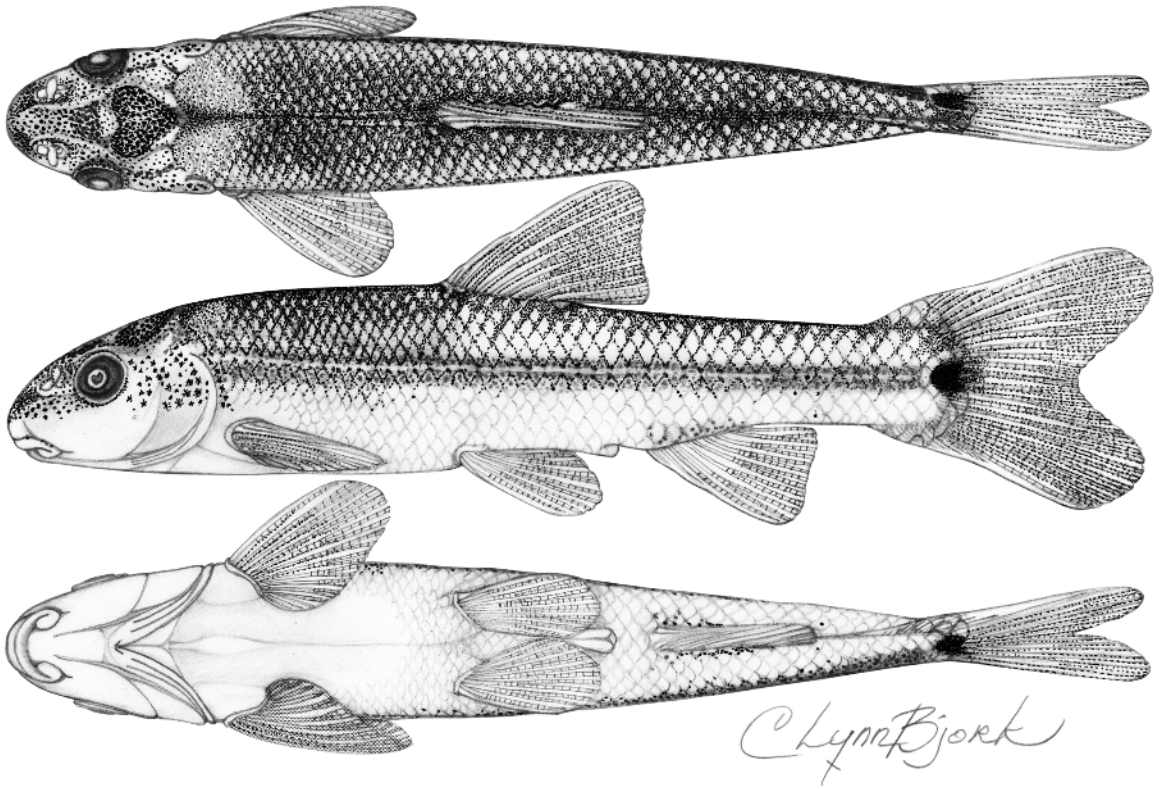

Fig. 8. *Phenacobius mirabilis* juvenile, 33.1 mm SL, 40.2 mm TL. (Collected on 28 August 2001 by Colorado State University Larval Fish laboratory from the Arkansas River, Prowers County, Colorado; from LFL 80762.)